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PROCESS FOR PRODUCTION OF ASPARAGUS-JUICE CONCENTRATE

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The purpose of this circular is to make information available to prospective manufacturers on a process for the production of an asparagus-juice concentrate suitable for use as a microbiological culture medium. Development of the process has been carried to a semi-plant scale and such further study as may be needed can be carried on readily by those interested in commercial production of the concentrate.

Laboratory studies have indicated that asparagus-juice concentrate has value as a medium for the culturing of useful micro-organisms. This conclusion was confirmed by the interest shown in samples submitted to large industrial users of culture media. Preliminary cost estimates indicated that the concentrate could be produced from cannery and packing-house waste at a competitive price, independently of other by-products that might be recovered.

Process Studies

Summary of preliminary laboratory and pilot-plant studies. During the past four asparagus-packing seasons experimental work has been conducted in the Western Regional Research Laboratory and at industrial plants on the recovery and use of asparagus juice. The first procedure investigated comprised disintegration of the raw asparagus butts, pressing the disintegrated butts in a hydraulic press, heating the expressed juice in order to coagulate and precipitate colloidal materials that otherwise interfere with concentration and cause cloudiness, and filtering. Further study showed that steam-blanching the butts and pressing without disintegration produced a juice that yielded clear concentrate without heating before filtration. The juice pressed from blanched butts was, however, comparatively low in nitrogen content.

Both the composition and quality of the juice are affected markedly by the extraction process. Since the nitrogen content of the juice appears to be a critical factor in its value as a microbiological culture medium, efforts were made to obtain maximum nitrogen content. It was found that "digesting" the cloudy press juice obtained from disintegrated raw butts for several hours at 122° F. (50° C.) and at pH 5 before filtering increased the soluble nitrogen content 15 to 35 percent above that contained in juice clarified by heating after pressing but not digested. The combination of disintegration of raw butts, pressing, digestion, and filtration yielded a juice containing an average of approximately 75 per cent more nitrogen than the juice obtained by blanching the whole butts, pressing in a hydraulic press, and filtering.

A preliminary engineering analysis of commercial-scale possibilities for preparation of asparagus-butt juice showed that the production costs could be

markedly decreased by making the pressing operation continuous, following disintegration of the raw butts. Some difficulty was experienced in clarifying the juice obtained from a continuous press, but this problem was solved through filtration studies with various filter aids. It was found that a clear juice could be made by a quasi-continuous process, with types of equipment potentially suitable for large-scale operation.

After semi-pilot-plant study had been given to the more difficult processing steps, the complete sequence of process steps was carried out. The raw asparagus butts were pulped in a Rietz disintegrator; the juice was separated from the gross fiber in a continuous screw press; it was adjusted to pH 5 with sulfuric acid and digested for 4 hours at a temperature of 122° F. (50° C.); after digestion it was heated to 167° F. (75° C.) to coagulate colloidal material; the juice was then filtered through a plate-and-frame filter press, with Dicalite No. 20 filter aid. The filtrate was concentrated in a laboratory vacuum evaporator and yielded a clear concentrate suitable for use as a culture medium.

During concentration, temperatures were carefully controlled to avoid caramelization or other harmful chemical changes. The juice concentrate was stored below room temperature, in order to prevent a gradual chemical deterioration. Other means for preventing this deterioration are being investigated in order to permit storage of the concentrate at ordinary temperatures.

Early cooperative work with commercial plants. During the course of these studies, several industrial groups cooperated and supplied assistance, especially in connection with plant trials on methods proposed by the laboratory workers. Golden State Co., Ltd., and Western California Canners, Inc., made the first attempts in cooperation with the Western Regional Research Laboratory, to prepare a concentrate, using a Rietz disintegrator and tomato-pulping equipment. An earlier effort to extract juice from asparagus butts had, however, been made at a plant of the California Conserving Co. under the auspices of the Canners League of California, with a Davenport press. Experiments had also been carried out by Libby, McNeill and Libby, using a disintegrator and a screw press for juice extraction.

Difficulty was encountered during these early investigations in concentrating the juices beyond about 40 percent solids, owing to the presence of considerable colloidal and suspended material resulting from rough treatment in the tomato pulpers. Since this colloidal material could not be removed readily by filtration, to permit further concentration, an attempt was made to dry the partially concentrated juice in a commercial spray drier. The preliminary trials were unsuccessful and further studies on this method of drying were not made because the equipment became unavailable. The spray drying of asparagus juice presents difficulties due to the presence of hygroscopic sugars and the sensitivity of the material to heat damage.

The preliminary work on preparation of a juice concentrate was continued cooperatively with Libby, McNeill and Libby at Sacramento, California, principally tor the purpose of obtaining a quantity of juice to be used in further evaluation studies at this Laboratory and also samples to be submitted to interested commercial laboratories.

Pilot-plant operations in 1944. The beginning of the 1944 asparagus season found the process studies sufficiently advanced to warrant a larger-scale test at a commercial plant. Such a test was carried out in the plant of Flotill Products, Inc., at Stockton, California. Several thousand pounds of good-quality concentrate was prepared and the feasibility of the process demonstrated.

The processing steps used at the Flotill Products cannery were the same as those tested in the semi-pilot-plant studies at the Western Regional Research Laboratory. The steps may be more easily followed by reference to the accompanying process flow sheet.

Asparagus waste was fed to a No. 18 Rietz disintegrator from the cutting-table waste conveyor. Any type of disintegrator designed to handle fibrous materials of high moisture content would probably operate satisfactorily. The pulp was discharged into a continuous screw press (both Rietz and Toulouse-Delorieau types were used), where the juice and pulp were separated. The moist fiber was discarded as waste. The juice was drained to a tank and pumped to the "digesters" at frequent intervals.

In the digesters the juice was adjusted to pH 5.0 and held at 122° F. for 4 hours, under mild agitation. After digestion, the temperature of the juice was raised to 167° F., to coagulate the colloidal and suspended material, and 100 lbs. of Dicalite No. 20 or Celite No. 512 filter aid was added per 1000 gallons, preparatory to filtration.

Filtration was carried out by means of a recessed-plate filter press, with cloth as a filter medium. The cloth was precoated with the same filter aid, at the rate of about 11 lbs. per 100 sq. ft. of filtering surface. This relatively high quantity of precoat was necessary because of the variation in the age and porosity of the filter cloths. After the precoat had been applied, the filtration was started at low pressure and the filter cycle was run with gradually increasing pressure until the rate became too low to be economical. The cake was then discharged and the cycle repeated. The filtrate was brilliant at all times and was drained directly into the evaporator feed tank.

The evaporators were of the mechanical-agitator type and were operated under vacuum produced by a water-jet condenser connected to a header. These pans were constructed of copper. Heat was supplied from a steam jacket. The juice was concentrated to 60-65 percent solids in a single-batch operation under an average vacuum of about 26.5 inches of mercury. After concentration the juice was packaged in 5-gallon tin cans, filled directly from the evaporators, and stored in a cold room.

The average composition of the concentrate was as follows: total solids, 65.3 percent; nitrogen, 3.55 percent; reducing sugars, 42.1 percent.

The juice showed some tendency to darken during concentration. Color formation is an indication of undesirable chemical changes and should be prevented if possible. Small amounts of sodium sulfite were added to some batches just before concentration, in an attempt to inhibit formation of color. The effectiveness of this procedure is indicated below.

Batch No.	Sodium sulfite added (percent based on weight of thin juice)	Color comparison after dilution (thin juice = 1)
1	0	4.5
2	0	3.0
3	0.025	1.4
4	0.0025	1.4

Operating problems. The equipment problems encountered were due in part to the equipment itself and in part to the method of operation.

Successful screw-press operation requires both suitable equipment and proper operating technique. Inadequate drainage at the feed end of the screw press, especially with large clearance between the screw and screw-housing, creates a high degree of slip, due to greater fluidity of the wetter feed. This decreases output and reduces pressure on the fiber cake, increasing its moisture content and thereby decreasing the quantity of separated juice. The degree of pulping in the disintegrator also has a marked effect upon the operation of the screw press. Pulping should be held to the minimum consistent with high juice yields.

Filter-press operation for asparagus juice is a difficult problem and can become costly if not properly done. Since cycles are relatively short, much time would be consumed in the breakdown and redressing of the plate-type press. A Sweetland type of filter press is preferable from the standpoint of labor cost.

Because of the high evaporation ratio, pans or evaporators requiring a relatively large volume of liquid to cover the heating surfaces are undesirable for the usual operation. A better method is to use the pan or evaporator body as a storage and evaporation chamber in conjunction with an external forced-circulation heat exchanger. Holding partially concentrated batches can thus be avoided to a large extent. Stainless-steel construction is desirable in order to avoid metallic contamination of the juice during concentration.

Since a digestion period of 4 hours is required to solubilize the nitrogenous substances in asparagus juice, overtime work is necessary in order to finish the waste produced in a cannery operating day. Asparagus butts can be stored, however, without noticeable deterioration, for a 24-hour period. A split-day operation is therefore advantageous. For example, with a digestion period of 4 hours, the disintegration and pressing can be carried on only during the first half of the operating day, at a rate fast enough to take an entire day's production of waste. Asparagus butts accumulated during the last half of the day can be held in storage for the next day's run.

Operating data. Data collected at the Flotill plant agreed essentially with those obtained in the semi-pilot-plant studies at the Western Regional Research Laboratory. Averages of raw-material and operating data taken from daily runs are summarized below.

Asparagus waste (raw material)	
Proportion of received asparagus, %	50
Amount processed daily, tons	11.3
Moisture content, %	92.3
Expressed juice	
Weight yield from pressed waste, %	63.5
Soluble solids, %	4.2
Soluble solids, proportion of total in waste, %	65.8
Weight per gal., lbs.	8.45
Wet fiber, moisture content, %	87.1
Digestion	
pH of raw juice	5.75
Sulfuric acid (66°Be) per 100 gal., cc.	53.5
Time, hrs.	4
Temp., °F.	122
Filtration	
Temp. for flocculation, °F.	167
Filter aid per 1000 gal., lbs.	100
Filter aid for pre-coat per 100 sq. ft., lbs.	11
Filtration rate, gal./sq.ft./hr.	5.0
Evaporation	
Total solids in juice, %	4.3
pH of juice	5.24
Total solids in concentrate, %	65.0
pH of concentrate	5.7
Engineering data	
Power load of disintegrator (at 1.5 tons/hr.), hp.	9.5
Power load of screw press (at 1.5 tons/hr.), hp.	1.8
Power load for agitating 1000 gal. juice, hp.	2
Equivalent power for pumping 15 gal./min., hp.	2
Steam pressure in evaporator, lbs./sq.in.	8
Evaporation rate, lbs. water/hr.	1,930
Av. heat transfer coefficient, B.t.u./sq.ft./hr./°F.temp.diff.	640

Processing costs. An estimate of processing costs, based on operation at the Flotill plant and including capital charges on the additional equipment required for operation of the process, but excluding general overhead, indicates that the asparagus-juice concentrate can be produced for approximately $0.72 per gallon, or $0.07 per pound, when 1100 tons of asparagus waste are processed during an operating season of 72 days.

An approximate breakdown of the cost factors involved in this estimate is given below as a rough guide for prospective producers:

Capital charges on equipment (3-year write-off)	50%
Labor	25%
Steam and electric power	15%
Other charges	10%

Opportunities for effecting improvements and economies in the process will be apparent to plant operators. For example, no attempt has been made to recover the 30 percent (or more) of the juice lost with the residual moist fiber from the screw press or the juice lost in the filter cake. Economical washing procedures for extracting the lost juice would result in a substantial reduction of the cost per unit of product. It is possible that at least a third of this lost juice can be recovered, without much additional cost, by better operation of the screw press.

Conclusions and Suggestions

The results of the pilot-plant test at the Flotill plant were generally satisfactory; a quantity of good-quality concentrate was produced without serious trouble in a semi-continuous operation involving only standard types of equipment.

Experience gained during the operation indicates that numerous improvements can be effected by further study. For example, a marked improvement in screw-press efficiency can almost certainly be obtained by slight changes in design to adapt the press to the material handled. The economy of filtration can be improved by the use of a Sweetland-type filter. A forced-circulation type of evaporator with relatively small volume of liquid in the heat exchanger at any time is better than a jacketed pan type of evaporator, because of the relatively large volume of concentrate required to cover the heat-transfer surface in the jacketed pan. A small amount of sulfite added to the juice helps to prevent darkening during concentration and has not been found detrimental in the subsequent use of the product as a culture medium.

Apparently the cost of production is reasonably similar to costs of other culture media. Possibilities for large-quantity production appear, however, to be dependent upon specific values that the asparagus juice may have as a culture medium.

The accompanying sketch shows a possible sequence of operations and general arrangement of equipment with all main operating units on the same floor. The disintegrator, screw press, filter press, and evaporator are all within observational range of the operator. With such an arrangement, the necessary periodic attention to each of the units is a relatively simple matter. As far as practicable, controls should be centralized at one point in this arrangement. The storage bin is an additional labor-saving feature, since it obviates the necessity for overtime operation on the latter portion of the day's waste.

Asparagus butts are dumped from the main waste conveyor into the storage bin. A screw conveyor feeds the waste at a controlled rate to the disintegrator, which discharges directly into the screw press. (The disintegrator should be flexible in its output to permit optimum operation of the screw press, probably the most critical unit in the whole process.) The juice drains into a floor tank and is pumped to the digesters. The digesters operate on a 4-hour cycle, as discussed previously. From the digesters the juice is pumped to the Sweetland-type filter press after addition of the proper amount of filter aid. The cloudy juice is returned to the digestion tank and refiltered. It is then pumped into the evaporator feed tank. The clear juice is pumped directly to the evaporator feed tank from the press.

At approximately the end of the half-day period, the disintegrator and screw press should be shut down and the storage bin allowed to fill with the rest of the day's waste, while the juice already in process is finished. The next day's operation is adjusted so that the storage bin is again empty at the half-day point.

Shortening the digestion time would be advantageous from the operating standpoint. Addition of a small amount of sulfite before digestion may increase the rate of solubilization of the nitrogen-bearing substances. Work is under way to determine the value of this procedure.

A number of technical controls on the operation are desirable to insure best operation Samples of the disintegrated raw waste, the residual fiber from the screw press, the raw juice, the digested juice, the filtered juice, and the final concentrate should be taken at regular intervals and subjected to such tests as may be necessary to determine whether the process is operating satisfactorily. For example, the digested juice should be tested in the laboratory periodically, as a means of determining the proper amount of filter aid.

Those interested in more detailed information regarding the manufacture of asparagus-juice concentrate by this method are invited to communicate with the Western Regional Research Laboratory.

ASPARAGUS WASTE PROCESSING FLOW SHEET